

U.S. Patent Application Serial No. 10/038,875
Response dated May 19, 2004
Reply to OA of February 20, 2004

IN THE CLAIMS

Please cancel claims 4, 5 and 16 without prejudice or disclaimer.

Please amend claims 1, 6, 11, 14, 15, 17 and 26, as follows:

Claim 1 (Currently amended): A proton-conducting membrane, comprising a three-dimensionally crosslinked silicon-oxygen structure (A), carbon-containing compound (B), and inorganic acid (C), characterized by wherein

a phase-separated structure containing a carbon-containing phase containing at least 80% by volume of the carbon-containing compound (B) and inorganic phase containing at least 80% by volume of the inorganic acid (C), the inorganic phase forming the continuous ion-conducting paths,

wherein said carbon-containing compound (B) is characterized by the skeleton section substituted with hydrogen at the joint with the three-dimensionally crosslinked silicon-oxygen structure (A), satisfying the following relationship:

$$(\delta p^2 + \delta h^2)^{1/2} < 7(\text{Mpa})^{1/2}$$

wherein, δp and δh are the polarity and hydrogen bond components of the three-component solubility parameter.

Claim 2 (Original): The proton-conducting membrane according to Claim 1, wherein said phase-separated structure is a sea-island structure with the carbon-containing phase as the island and inorganic phase as the sea.

U.S. Patent Application Serial No. 10/038,875
Response dated **May 19, 2004**
Reply to OA of **February 20, 2004**

Claim 3 (Original): The proton-conducting membrane according to Claim 1, wherein said phase-separated structure is composed of a carbon-containing phase and inorganic acid phase both in the form of continuous structure.

Claim 4 (Canceled).

Claim 5 (Canceled).

Claim 6 (Currently amended): The proton-conducting membrane according to Claim 5 1, wherein said carbon-containing compound (B) is bound to the three-dimensionally crosslinked silicon-oxygen structure (A) via 2 or more bonds.

Claim 7 (Original): The proton-conducting membrane according to Claim 6, wherein the skeleton section of said carbon-containing compound (B) is a hydrocarbon consisting of carbon and hydrogen.

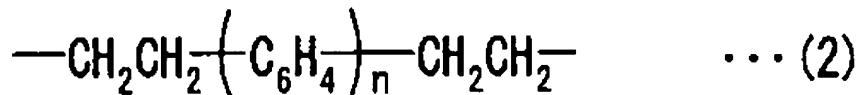
Claim 8 (Original): The proton-conducting membrane according to Claim 7, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (1):

U.S. Patent Application Serial No. 10/038,875
Response dated May 19, 2004
Reply to OA of February 20, 2004



wherein, "n" is an integer of 2 to 20.

Claim 9 (Original): The proton-conducting membrane according to Claim 7, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (2):



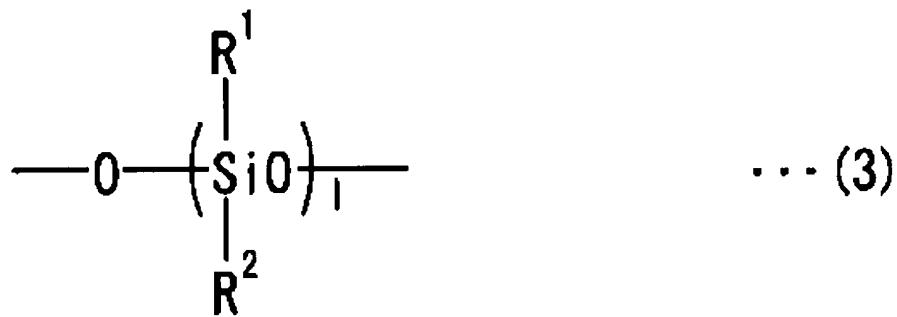
U.S. Patent Application Serial No. 10/038,875

Response dated May 19, 2004

Reply to OA of February 20, 2004

wherein, "n" is a natural number of 4 or less.

Claim 10 (Original): The proton-conducting membrane according to Claim 6, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (3):



wherein, R^1 and R^2 are each a group selected from the group consisting of CH_3 , C_2H_5 and C_6H_5 ; and "l" is an integer of 2 to 20.

Claim 11 (Currently amended): The proton-conducting membrane according to Claim 4 1, wherein said inorganic acid (C) is a heteropoly acid.

U.S. Patent Application Serial No. 10/038,875
Response dated May 19, 2004
Reply to OA of February 20, 2004

Claim 12 (Original): The proton-conducting membrane according to Claim 11, wherein said heteropoly acid is used in the form of being supported beforehand by fine particles of a metallic oxide.

Claim 13 (Previously Presented): The proton-conducting membrane according to Claim 11, wherein said heteropoly acid is a compound selected from the group consisting of tungstophosphoric, molybdophosphoric and tungstosilicic acid.

Claim 14 (Currently amended): The proton-conducting membrane of according to Claim 4 1, which contains 10 to 300 parts by weight of the inorganic acid (C) per 100 parts by weight of the three-dimensionally crosslinked silicon-oxygen structure (A) and carbon-containing compound (B) totaled.

Claim 15 (Currently amended): A method for producing the proton-conducting membrane of any one of Claims 1 to 3 comprising a three-dimensionally crosslinked silicon-oxygen structure (A), carbon-containing compound (B) bound to (A) via a covalent bond, and inorganic acid (C), said method comprising steps of preparing a mixture of a carbon-containing compound (D) having one or more hydrolyzable silyl groups and said inorganic acid (C), forming the above mixture into a film, and hydrolyzing/condensing the hydrolyzable silyl group contained in the mixture formed into the film, to form said three-dimensionally crosslinked silicon-oxygen structure (A),

U.S. Patent Application Serial No. 10/038,875
Response dated May 19, 2004
Reply to OA of February 20, 2004

wherein the skeleton section of said carbon-containing compound having one or more hydrolyzable silyl groups (D) whose hydrolyzable silyl group(s) are substituted by hydrogen satisfies the following relationship:

$$(\delta p^2 + \delta h^2)^{1/2} < 7(\text{Mpa})^{1/2}$$

wherein, δp and δh are the polarity and hydrogen bond components of the three-component solubility parameter.

Claim 16 (Canceled).

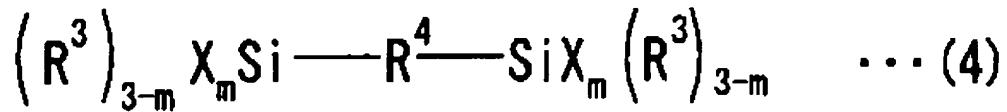
Claim 17 (Currently amended): The method according to Claim 16 15 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups has 2 hydrolyzable groups.

Claim 18 (Original): The method according to Claim 17 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (4):

U.S. Patent Application Serial No. 10/038,875

Response dated May 19, 2004

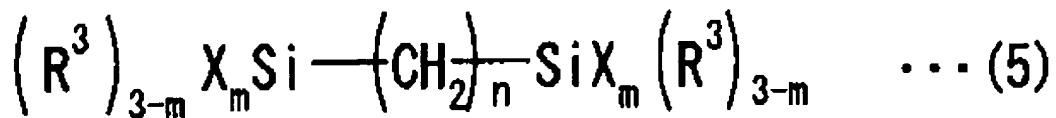
Reply to OA of February 20, 2004



wherein, R^3 is a group selected from the group consisting of CH_3 , C_2H_5 and C_6H_5 ; R^4 is a hydrocarbon compound consisting of carbon and hydrogen; X is a group selected from the group consisting of Cl , OCH_3 , OC_2H_5 and OC_6H_5 ; and “ m ” is a natural number of 3 or less.

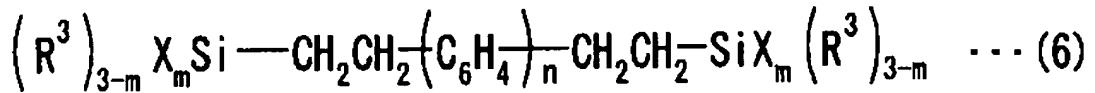
Claim 19 (Original): The method according to Claim 18 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (5):

U.S. Patent Application Serial No. 10/038,875
Response dated May 19, 2004
Reply to OA of February 20, 2004



wherein, R^3 is a group selected from the group consisting of CH_3 , C_2H_5 and C_6H_5 ; X is a group selected from the group consisting of Cl , OCH_3 , OC_2H_5 and OC_6H_5 ; “ m ” is a natural number of 3 or less; and “ n ” is an integer of 2 to 20.

Claim 20 (Original): The method according to Claim 18 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (6):



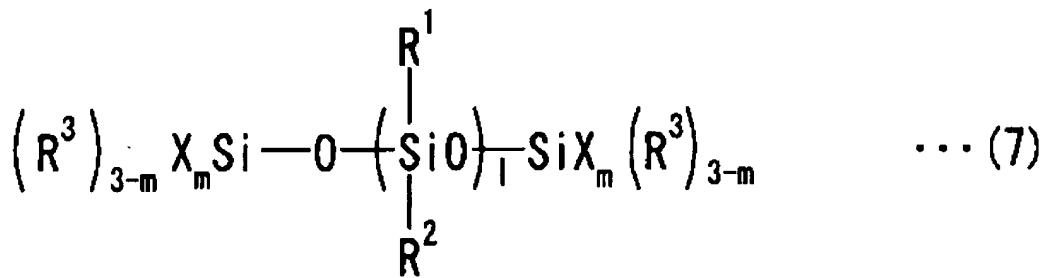
U.S. Patent Application Serial No. 10/038,875

Response dated May 19, 2004

Reply to OA of February 20, 2004

wherein, R^3 is a group selected from the group consisting of CH_3 , C_2H_5 and C_6H_5 ; X is a group selected from the group consisting of Cl , OCH_3 , OC_2H_5 and OC_6H_5 ; “ m ” is a natural number of 3 or less; and “ n ” is a natural number of 4 or less.

Claim 21 (Original): The method according to Claim 17 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (7):



wherein, R^1 , R^2 and R^3 are each a group selected from the group consisting of CH_3 , C_2H_5 and C_6H_5 ; X is a group selected from the group consisting of Cl , OCH_3 , OC_2H_5 and OC_6H_5 ; “ m ” is a natural number of 3 or less; and “ l ” is an integer of 2 to 20.

U.S. Patent Application Serial No. 10/038,875

Response dated May 19, 2004

Reply to OA of February 20, 2004

Claim 22 (Original): The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) uses water (E) to be contained in said mixture.

Claim 23 (Original): The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is effected at 5 to 40°C for 2 hours or more.

Claim 24 (Original): The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is followed by an aging step effected at 100 to 300°C.

Claim 25 (Original): The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is followed by a step in which a compound (F) having a hydrolysable silyl group is spread and hydrolyzed/condensed, effected at least once.

U.S. Patent Application Serial No. **10/038,875**

Response dated **May 19, 2004**

Reply to OA of **February 20, 2004**

Claim 26 (Currently amended): A fuel cell which incorporates the proton-conducting membrane of any one of Claims 1 to 3.